SECTION 16203

TRACTION POWER EQUIPMENT GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 DESCRIPTION

A. This Section specifies the general requirements for the supply and delivery of new traction power substation equipment including AC switchgear units, transformer/rectifier unit, DC switchgear units, interconnecting bus duct, and DC disconnect switch assemblies. Specific requirements for each substation equipment item are included in subsequent sections of these Specifications.

1.02 MAJOR ELECTRICAL EQUIPMENT

A. Major electrical equipment includes the following:

1. 15 kV AC switchgear assembly
2. Rectifier transformer(s)
3. Rectifier(s)
4. 750 volt DC switchgear assembly
5. Anode (AC) bus and Cathode (DC) bus
6. Negative bus and Drainage Board
7. DC Feeder Disconnect Switches
8. 15 kV circuit breaker control and indication panel
9. DC circuit breaker test cabinet
10. 15 kV ground and test device
11. AC circuit breaker test cabinet
12. Station battery, charger and accessories
13. Technical Support Equipment
14. Supervisory Equipment (SCADA) System
15. 125 VDC Control Voltage Distribution System

1.03 REFERENCES

A. All major electrical equipment furnished under this Contract shall be in accordance with the latest applicable standards of NEMA, IEEE, ANSI,

NFPA, ICEA, OSHA, UL, National Electrical Code and Massachusetts Electrical Code with regard to material, design, construction and testing, except for variations as specified in the Specification. The standards applicable shall include, but not be limited to the following:

1.	ANSI 34.2	Practices and Requirements for Semiconductor Power Rectifiers
2.	ANSI C37.06	AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis Preferred Ratings & Related Required Capabilities
3.	IEEE C37.09	Test Procedure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4.	IEEE C37.1	IEEE Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control
5.	ANSI C37.2	IEEE Standard Electrical Power System Device Function Numbers
6.	IEEE C37.11	Requirements for Electrical Control for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
7.	IEEE C37.13	Low Voltage AC Power Circuit Breakers Used in Enclosures
8.	IEEE C37.14	Low Voltage DC Power Circuit Breakers Used in Enclosures
9.	ANSI C37.16	Low Voltage Power Circuit Breakers and AC Power Circuit Protectors Preferred Ratings, Related Requirements, and Application Recommendations
10.	ANSI C37.17	Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers
11.	IEEE C37.20.1	Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear
12.	IEEE C37.20.2	Metal-Clad and Station-Type Cubicle Switchgear
13.	ANSI C37.32	High Voltage Air Switches, Bus Supports, and Switch Accessories Schedules of Preferred Ratings, Manufacturing Specifications, and Application Guide

14.	IEEE C37.34	Standard Test Code for High-Voltage Air Switches
15.	IEEE C37.40	Service Conditions and Definitions for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories
16.	ANSI C37.90	Relays and Relay Systems Associated with Electric Power Apparatus
17.	ANSI C39.1	Requirements for Electrical Analog Indicating Instruments
18.	ANSI C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers
19.	ANSI C57.12.10	Transformers 230 kV and Below – Safety Requirements
20.	ANSI C57.12.50	Ventilated Dry-Type Distribution Transformers 1 to 500 kVA Single-Phase and 15 to 500 kVA Three-Phase,
21.	ANSI C57.12.51	Ventilated Dry-Type Power Transformers, Three-Phase, 501 kVA and Larger
22.	ANSI C57.12.91	Test Code for Dry-Type Distribution and Power Transformers
23.	ANSI C57.13	IEEE Standard Requirements for Instrument Transformers
24.	ANSI C57.13.2	Conformance Test Procedures for Instrument Transformers
25.	ANSI C57.18.10	IEEE Standard Practices and Requirements for Semiconductor Power Rectifier Transformers
26.	ANSI C57.110	IEEE Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents
27.	ANSI B1.1	Unified Inch Screw Threads
28.	ANSI B1.10-58	Unified Miniature Screw Threads
29.	ANSI Z55.1.61	Gray Finishes, Light Gray Color Chip No. 61
30.	ANSI 634	Cable Penetration Fire Stop Qualification Test
31.	IEEE 4	Standard Techniques for High Voltage Testing

32.	IEEE 48	Standard Test Procedures and Requirements for Alternating Current Cable Terminations 2.5 kV Through 765 kV
33.	IEEE C62.11	IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1 kV)
34.	IEEE 82	IEEE Standard Test Procedure for Impulse Voltage Tests on Insulated Conductors
35.	ICEA S-73-532 (NEMA WC 57)	Standard for Control Cables
36.	ICEA S-95-658 (NEMA WC70)	Standard for Nonshielded Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
37.	ICEA S-96-659 (NEMA WC71)	Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electrical Energy
38.	ICEA S-93-639 (NEMA WC 74)	Nonshielded Power Cables Rated 5000-46000 Volts for the Distribution of Electrical Energy
39.	NEMA AB 3	Molded Case Circuit Breakers and Their Application
40.	NEMA FU-1	Low Voltage Cartridge Fuses
41.	NEMA ICS 1	Industrial Control and Systems: General Requirements
42.	NEMA ICS 4	Industrial Control and Systems: Terminal Blocks
43.	NEMA KS 1	Enclosed and Miscellaneous Distribution Equipment Switches
44.	NEMA LA 1	Surge Arresters
45.	NEMA LS 1	Low Voltage Surge Protection Devices
46.	NEMA PE 5	Utility Type Battery Chargers
47.	NEMA RI 9	Silicon Rectifier Units for Transportation Power

	Supplies
48. NEMA SG 4	Alternating Current High Voltage Circuit Breaker
49. NEMA SG 6	Power Switching Equipment
50. NEMA ST 20	Dry-Type Transformers for General Applications
51. NEMA TR 1	Transformers, Regulators, and Reactors
52. NEMA 250	Enclosures for Electrical Equipment (1000V Max.)
53. UL-44	Thermoset-Insulated Wires and Cables
54. UL-224	Extruded Insulating Tubing
55. UL-508	Industrial Control Equipment
56. UL-1008	Transfer Switch Equipment

B. Where any requirements specified herein or shown on the Contract Drawings exceed those of the above listed standards, the Contractor shall adhere to the higher standard. In case of conflict in requirements between two or more standards, the decision of the Engineer shall be final.

C. In cases where equipment from U.S. suppliers is not available, equivalent British, European, Japanese or IEC standards are acceptable, provided a tabulation is furnished citing the comparison between the applicable U.S. and the equivalent non-U.S. standards. In addition, the non-U.S. suppliers shall note where U.S. standards are not met, for evaluation and approval by the Engineer. Factory testing shall be performed whenever possible. If factory testing must occur outside of the USA, then the Contractor shall bear the costs associated with the witness testing by the MBTA's Engineer and one additional MBTA representative.

D. All equipment and materials furnished under Division 16 shall conform to all Federal, State or Municipal laws or ordinances, and if any requirement shown or specified conflicts with such laws or ordinances, the Contractor shall make such changes as are necessary to meet said requirements. The cost of such changes shall be borne by the Contractor and shall be included in the Contractor's original bid. Where any standards shown on contract plans or specified herein exceed the minimum standard set by law, the Contractor shall adhere to the higher standard.

E. Where materials or equipment are specified to conform to the standards of the Underwriters Laboratories, Inc., or to be constructed or tested in accordance with the standards of the National Electrical Manufacturers' Association or American National Standards Institute, the Contractor shall submit proof that the item furnished conforms to such requirements. The label of, or listing by the Underwriters' Laboratories, Inc. will be acceptable as sufficient evidence that the item is in accordance with the Underwriters' Laboratories standard. A company listed as a member company of NEMA for an item under consideration will be

acceptable as sufficient evidence that the item conforms to the requirements of the National Electrical Manufacturers Association. In lieu of such stamp or certification label listing, the Contractor may submit a written certificate from any nationally recognized testing agency adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the requirements listed herein including methods of testing by the specified agencies. Conformance with the agency requirement does not relieve the item from complying with any other requirements of the Specifications.

1.04 GENERAL

A. The design of the equipment shall provide features for the safety of personnel during operation, maintenance, and repair.

B. All equipment and materials supplied by the Contractor shall be new, of recent manufacture and of highest grade as specified. They shall be resistant to moisture and corrosion to withstand their environment and operational conditions with minimum maintenance and long life.

C. Wherever practicable, all major electrical equipment and materials furnished under this Contract shall be the product of a single manufacturer. In the case of major items, the manufacturer shall maintain a service organization within a reasonable distance from the project which is properly staffed and equipped to make repairs as required.

D. Materials and equipment shall be essentially the products of a manufacturer regularly engaged in the manufacturing of the product and the manufacturer shall have such products of comparable capacity and function to that specified in satisfactory use on a rapid transit system.

1.05 MANUFACTURER'S DRAWINGS

A. All units of measurement of length-weight-time shall be in the United States system of feet-pounds and seconds. Unit of measurement of temperature shall be in degrees Celsius, denoted by degrees C. Drawings may use metric dimensions and tolerances provided the equivalent United States units are clearly shown in parenthesis on all drawings defining General Arrangements and Interfaces, and on all drawings used for installation, repair, maintenance or disassembly. Drawings shall be prepared using terms and units standard to U.S. industry.

B. Unit of measurement for wire and cables shall be American Wire Gauge (AWG) up to size 4/0 and circular mils for larger sizes. Conductor stranding shall be as per ASTM.

C. All drawings shall be in English language only, irrespective of country of origin.

D. All drawings shall have a blank 3-inch x 4-inch space on the top right hand corner, clear of all markings, for approval stamping by the Engineer. If the Contractor's standard drawing does not provide this space, the drawing shall be prepared on the next larger sheet, or the 3-inch x 4-inch space may be provided elsewhere on the drawing.

E. The submittal requirements identified in Section 16311 shall be observed by the Contractor. The process of highlighting drawing changes for progress submittals shall be complied with.

1.06 BUS AND BUS CONNECTIONS AND JOINTS

A. The buses within equipment supplied by the Contractor shall be fabricated of high conductivity rectangular copper bars as specified herein. Aluminum may be used for rectifier heat sinks. Buses shall be designed to carry rated currents without exceeding the maximum allowable temperature rise as specified in ANSI, NEMA and IEEE standards when operating at specified overloads. Bus connections and joints shall have an ampacity equal to that of the bus ampacity, and be fabricated so that there will be no loss of conductivity during the life of the equipment.

B. The entire contact area of all bolted current carrying connections in copper buses shall be factory silver-plated. Ring-plated method of silver plate and tin-plated contact surfaces will not be acceptable. Silicon bronze bolts, nuts and lockwashers, or approved equal, shall be used. Connections shall be made with a minimum of two ½ inch - 13 bolts at each end of the joint.

C. All bolted current carrying connections in aluminum heat sink assemblies of rectifiers, where approved by the Engineer, shall be first copper plated, then nickel plated and provided with proper spring tensioning devices to maintain proper joint pressure under load (heat) cycle. Stainless steel bolts, nuts and lockwashers shall be used.

D. The Contractor shall coordinate all connections to mate with adjacent equipment terminals and enclosures. Provisions shall be made for access to permit assembly of these connections and inspection after installation or removal without displacing the major components within the enclosure.

1.07 POWER AND GROUNDING CONNECTORS

A. All terminal lugs furnished for power and grounding cables shall be heavy duty, bolted type, of high copper content alloy, complete with silicon bronze bolts, nuts and lockwashers. Lugs shall have tongues with either two or four ½ inch - 13 bolts, as specified, spaced per standard NEMA drillings, and four-bolt cable clamps. All contact surfaces shall be machined smooth and silver-plated.

1.08 NAMEPLATES

A. Each major component of equipment shall have, as a minimum, the manufacturer's name, address, and catalog number, model, style or type on a nameplate securely attached to the item in an area easily accessible to normal visual demands by maintenance and service personnel. Nameplates for electrical apparatus shall conform to the referenced standards and as specified elsewhere in this Specification.

B. Each rectifier and transformer, switchgear assembly unit, circuit breaker and auxiliary unit, auxiliary transformer, bus ducts, battery charger, panel board, terminal box, and all panel mounted and individually mounted equipment and

devices shall be provided with nameplates for proper identification. Panel and door mounted devices shall also be identified in the rear with the designations indicated on manufacturer's connection diagrams. Internally mounted devices shall be similarly identified with nameplates and manufacturer's connection diagram designations.

C. Nameplates identifying major equipment shall be provided in duplicate: one on front and the second on the rear of the equipment.

D. Nameplates identifying AC and DC circuit breaker and auxiliary units shall have inscription including circuit breaker number and service. One nameplate shall be provided on front, the second on the rear of each unit.

E. Nameplates for panel boards, terminal boxes and similar equipments shall have lettering in accordance with MBTA standards.

F. Nameplates for panel and door mounted relays, meters, control and instrument switches, fuses and auxiliary devices and individually mounted circuit breakers, disconnect switches, etc., shall have 1/4 inch, minimum, lettering. For protective and auxiliary relays, the nameplate inscription shall include device number and function. Nameplates for fuses shall note the type and rating of fuse, polarity and identify the circuit.

G. All nameplates shall be laminated plastic with dull white surface and black core unless otherwise specified. Letters shall be engraved through outer layer to expose black core. All exposed edges shall be beveled. Nameplates shall be fastened with machine screws. Use of self-tapping screws or adhesives will not be permitted.

H. The legends of all nameplates shall be submitted to the Engineer for approval.

1.09 WIRING AND TERMINAL BLOCKS

A. Wiring

16. All secondary and control wiring in equipment, including wiring on removable elements of circuit breakers, shall be ICEA/NEC type SIS, or approved equal, stranded tinned copper switchboard wire, rated for a minimum conductor temperature of 90 degrees C. Wire shall be insulated for 600 volts unless otherwise specified. Wire shall comply with UL-44 for flame retardant properties for thermo-plastic insulated wire. Wire crossing hinged joints shall be similar except extra flexible, suitably protected against abrasion.

17. Wiring to and from the rectifier and DC switchgear (including integral 15kV AC control panel) shall have minimum insulation rating of 1000V DC.

18. Current and potential transformer secondary wiring and control circuit wiring, including wiring between equipment, shall be No. 12 AWG, or larger, unless otherwise specified.

19. Wiring shall be provided with ring-type compression terminals with insulated

sleeves at each termination. All wiring shall be identified at each termination by printing on wire jacket or on an insulating sleeve. Adhesive wire markers are not acceptable.

20. Wiring installed through openings in metal barriers or structural members shall be protected against abrasion by approved grommets.

21. Wire harnesses shall be supported with a bracket fastened to the enclosure via a tack-welded stud or a machine screw utilizing a "shake-proof" washer. Welding and/or drilling and tapping for machine screws shall be accomplished before finish paint is applied. Nylon composite tie wraps shall be used for securing harness to the support. Wire support brackets attached to the enclosure with adhesives are not acceptable.

22. Analog indication wiring to SCADA shall be No. 16 AWG or larger, unless otherwise specified.

B. Terminal Blocks

23. Circuits requiring external connections shall be factory-wired to terminal blocks, readily accessible for field wiring entering from top or bottom as specified for the equipment involved. Sufficient number of terminals to satisfy all external connection requirements and 20 percent additional unassigned terminals shall be provided. Terminal blocks shall be heavy-duty, washer-head screw type with insulating barriers between circuits, rated 600 volts, unless otherwise specified, complete with marking strips and plastic covers. Similar terminal blocks, complete with properly tagged jumper wires, shall be provided at each shipping split to facilitate field assembly.

24. Current and potential transformer secondary leads shall be wired directly to terminal blocks before being wired to relaying, metering or control devices. Terminal blocks for current transformer leads shall be short-circuiting type. For multi-tap or multi-ratio devices all taps shall be wired to adjacent terminal blocks.

1.13 RELAYS, SWITCHES AND DEVICES

A. General

1. The type of relays, switches and devices used in the control and supervision of the supplied equipment shall have proven record of successful operation in similar application to the satisfaction of the Engineer.

A. Relays and Meters

1. All single-function protective relays shall be of draw-out construction, provided with semi-flush mounting cases. Relays shall be connected to external wiring through built-in test switches or connection blocks arranged to allow in case testing of the relay. Single-function and multi-function protective relays shall be microprocessor based with resettable targets (flags), and 125 VDC control. Current versions of the relay software shall be provided with each relay. The relays shall have facility or communication to a laptop PC.

2. All control and auxiliary relays shall be front connected, surface mounting type, with cover, suitable for use in switchgear equipment in accordance with ANSI C37.90. Operating coils of direct current relays shall be suitable for continuous operation between 80 percent and 110 percent of rated voltage and for alternating current relays between 85 percent and 110 percent of rated voltage.

3. The coils of interposing relays, Devices 201C and 201T, for interfacing with supervisory system equipment shall be rated for operation on 125 volts DC and shall have a burden of not more than 12.5 watts. Coils shall be provided with surge limiting diodes to suppress noise during operation which may cause momentary false indication. Contacts shall be rated 30 amperes DC, minimum.

4. Auxiliary relays shall be rated for 750 volts DC service, minimum. Relays shall be isolated from equipment enclosures for 1,000 volts DC, minimum.

5. Pickup of relays for cable energized indication, Device 197X, of DC traction feeder circuits shall be adjustable for a minimum range of 400 volts to 750 volts.

6. All indicating instruments shall be switchboard type, one percent accuracy, semi-flush mounted having metal scales with black figures on white background. They shall be approximately 4-1/2 inches square with a minimum of 240-degree scale, furnished with anti-glare glass, unless otherwise specified.

7. Ammeters for space heater circuits shall be panel type, two percent accuracy, semi-flush mounting, approximately 2-1/2 inch square. A red mark shall indicate the normally expected current reading.

8. All meters shall be provided with insulating covers on exposed terminals.

A. Switches

1. All control, selector and instrument switches shall be rotary type, provided with properly designated black escutcheon plates, clearly marked with white letters to show operating position. General Electric type SBM, Shallco Series 26, Electroswitch Series 24 or Type W2 or approved equal.

2. Breaker control switches shall be spring-return to normal with escutcheon engraved TRIP-CLOSE, trip counter-clockwise, close clockwise, furnished with target and red pistol grip handle.

3. Breaker control mode selector switches, Devices 43 and 143, shall be three-position, maintained contact type with escutcheon engraved LOCAL-OFF-SUPV, off position at 12 o'clock, with black oval handle.

4. Instrument switches shall be maintained contact type, shall have an OFF position and black knurled round handle.

5. Load measuring circuit bypass switch shall be key-operated, two position,

with escutcheon engraved "NORMAL-OPERATED", maintained contact type. Key shall be held captive at "OPERATED" position. All switches shall be set to operate with the same key. Information related to lock setting and number of keys to be supplied will be furnished by the Engineer.

6. At least one of each type of switch shall be provided as spare parts along with the equipment, unless otherwise identified.

B. Test Switches

1. Test switches shall be provided for in-service testing and calibration of indicating instruments, transducers and other devices not furnished with built-in test devices, for removal of these devices from potential and current circuits without disturbing switchgear wiring. Test switches are not required for devices on DC switchgear.

2. Each test switch shall be provided with a minimum of three poles for potential circuits and six poles for current circuits. Current switches shall be provided with features for short-circuiting current transformer secondaries prior to disconnecting the instruments and devices from current circuits. The individual switch units shall be assembled on an insulated base provided with insulated barriers between each pole. Test switches shall be arranged for semi-flush mounting in front of the switchgear. Contractor shall furnish a set of necessary test plugs and jumper cables with the switchgear assembly.

C. Indicating Lamps

1. All indicating lights shall be of the light emitting diode (LED) type, mounted in assemblies which include an appropriate series resistor, hardware for panel mounting, and colored lenses. LED element(s) shall be mounted on a socket to facilitate replacement and shall have a rated life of 100,000 hours, minimum.

2. Internal surfaces of the lenses shall be Fresnel-cut to produce a brilliance comparable to that of a low-burden incandescent light unit.

D. Fuses and Fuse Holders

1. All fuses for control, auxiliary, and metering circuits shall be located in such a position that they are easily and safely accessible. Fuses shall be of the non-renewable, cartridge type, with “finger-safe” holders where available.

2. Fuse holders and fuses installed in solidly grounded equipment assemblies shall be rated for 250 volts AC service. Fuses shall have a minimum interrupting rating of 20,000 amperes rms, symmetrical, at 250 volts AC and DC.

3. Fuse holders and fuses installed in rectifier units and in DC switchgear for control and auxiliary circuits shall be rated for 1,000 volts DC service. Fuses shall have a minimum interrupting rating of 20,000 amperes, rms, symmetrical, at 600 volts AC or DC.

4. Fuse holders and fuses for metering circuit taps to 600-volt nominal DC power buses at rectifier DC switchgear shall be rated for application on systems capable of delivering DC short circuit current of 200,000 amperes. Fuse holder shall be designed to reject fuses of lower interrupting ratings. Fuses shall be either pull-out mounted or the bolted-on type. Disconnect means shall be provided with bolted-on fuses, for safe disconnection of the fuse holder from the energized bus.

E. Protection and Control Equipment Voltage Ratings

1. Auxiliary relays, control and selector switches, fuse holders and fuses, terminal blocks and other devices which are located in the rectifier unit and DC switchgear and which operate on 125 VDC may be rated for 600 volts AC or DC insulation only under the following conditions:

   a. Similar 1000VDC rated devices are not available; and

   b. Such devices are insulated for 1,000 volt, minimum, from equipment enclosure.

1.13 TRANSDUCERS AND ISOLATION AMPLIFIERS FOR TELEMETERING AND LOCAL INSTRUMENTATION

A. Transducers

1. General

   a. Transducers for converting the measured AC and DC quantities into DC milli-ampere signal for telemetering via Authority's SCADA system shall be of the solid state design, suitable for installation in switchgear equipment.

   b. The transducers shall be of the 0.5 percent accuracy class, having a DC output signal linearly proportional to the measured quantity. Devices shall have an operating temperature range from minus 15 degrees C to plus 65 degrees C, minimum, and shall perform satisfactorily in an atmosphere containing up to 95 percent humidity (noncondensing). Transducers shall withstand for one minute a hi-pot test of 1,500 Volts, rms, 60 Hz applied between the input and output circuits and from input and output circuits to ground. Output shall be adjustable within plus-minus 10 percent of the full output range.

   c. Potential circuits of transducers shall be designed for continuous operation at 20 percent higher than the rated voltage. Current circuits shall be capable of continuous operation at twice the rated current and shall withstand a fault current of 250 amperes for one second.

2. Ratings: Transducers shall have the electrical ratings and characteristics specified below:

   a. For measuring AC voltage and current:

	Voltage Transducers	Current Transducers	
Input, 60 Hz	0-150 V	0-5 A	
Output - DC into 10 k ohm load	0-1 mA	0-1 mA	
Output ripple - peak, max.	1 percent	1 percent	
Response time for 0-99 percent output, max.		400 msec.	400 msec.
Linearity - percent of full scale	0.25	0.25	

b. For measuring DC voltage:

Input, DC		0-750 V
Output DC into 10k ohm load	0-1 mA	
Response time for 0-99 percent output, max.		1 sec.
Linearity - percent of full scale	0.5	

c. For measuring DC power:

Input, DC:		
Voltage	0-750 V	
Current	0-50 mV, from shunt	
Output DC to load	determined by Contractor	
Response time for 0-99 percent output, max		1 sec.
Linearity - percent of full scale	0.5	

B. Isolation Amplifiers and Power Supply

1. For telemetering rectifier DC current, DC traction feeder currents and DC drainage currents via Authority's SCADA system, the millivolt signal, obtained from shunts at the circuit breakers, shall be insulated from the supervisory equipment at the substations by use of isolation amplifiers. An isolation amplifier, suitable for installation in the DC switchgear assembly, shall be furnished for each rectifier and traction feeder circuit.

2. Isolation Amplifier

a. The isolation amplifiers shall be of high precision, low non-linearity, three-port insulation design, having an operating temperature range from minus 15 degrees C to plus 65 degree C, minimum. The device shall be designed to withstand for one minute a hi-pot test of 2,500 volts, rms, 60 Hz applied from input port to output port and from input port to power supply. The isolation amplifier shall be designed to operate on DC supply derived from an external power source.

b. Isolation amplifiers shall have the electrical ratings and characteristics specified below:

Input differential

For rated linearity	1-10 Volts DC*
Continuous	120 Volts, rms
For 1 minute	240 Volts, rms
Gain, adjustable	1 Volt/1 Volt -to-1 Volt/100 Volts**

Output nonlinearity

Error at 10 volt P-P output	± 0.25 percent
Power supply range	15-25 Volts DC
	*With 1 Volt/1 Volt gain
	**Use external potentiometer, if required

3. Power Supply

   a. Contractor shall furnish a self-contained DC power supply for the isolation amplifiers. The power supply shall employ solid-state circuitry and shall have a regulated, filtered output.

   b. The power supply shall be rated to simultaneously power all isolation amplifiers. The output of the power supply shall be fully insulated from the input and be protected with suitable circuit breakers or fuses. All components shall be assembled in a metal enclosure, suitable for installation in the DC switchgear assembly.

   c. The power supply shall have the following ratings:

      (1) Input: 120 Volts AC (from reliable AC supply)
      (2) Output
          Voltage: 15-25 Volts DC, adjustable
          Current: 3.0 Ampere, minimum

   d. The power supply shall include, but not be limited to, the following accessories:

      (1) 1 - Red indicating LED for AC supply "on"
      (2) 1 – Output voltmeter
      (3) 1 - Voltage adjusting rheostat

1.12 ANNUNCIATORS

A. Annunciator shall be solid-state type, having back lighted nameplates, integral flasher and all auxiliary devices necessary for the operation and functions specified below. All component parts of an annunciator unit shall be assembled in a cabinet, with black bezel, suitable for flush panel mounting. Configuration and number of alarm points of the annunciator are specified in Article 1.05 of Section 16311.

B. Annunciator shall be rated for operation on 125 volts DC, supplied by the station battery. Annunciator circuit elements shall be protected from voltage spikes of the magnitudes and duration generated in the supply circuit under normal operation of the substation equipment. Protection shall be not less than a positive square wave of 3,000 volts for ten microseconds.

C. Annunciator shall be suitable for continuous operation over a supply voltage range of 105 to 135 volts DC. Alarm actuating circuits shall operate on 125 volts DC, arranged for both normally open and normally closed field trouble contacts. The arrangement for each alarm activation circuit shall be individually field settable.

D. Annunciator windows shall be approximately three inches wide by two inches high, having white nameplates with black engravings. A separate window shall be provided for each annunciator point. Each window shall be backlighted with two six-watt lamps in parallel. Minimum average life of lamps at operating voltage shall be 15,000 hours. Contractor shall prepare and forward to the Engineer, for approval, the nameplate engravings tabulation, showing a separate column for each line on the window. Engravings shall be based on the list of alarm functions specified in Article 1.05 of Section 16311. Engraved letters shall be approximately 1/4 inch high.

E. The annunciator system shall be provided with three push-buttons for acknowledge, test and reset functions.

F. Sequence modules shall be modular, plug-in type. One sequence module shall be furnished for each annunciator point, including spare points. Sequence of operation shall be as follows:

1. Normal condition: Window lamps off and alarm off.

2. Abnormal condition: Window lamps for the point affected shall flash and the alarm shall sound.

3. Return to normal before acknowledge: Window lamps for the point affected shall continue to flash and the alarm shall continue to sound.

4. Acknowledge: Window lamps for the point affected shall go to steady-on and the alarm shall be silenced.

5. Return to normal: Window lamp shall remain at steady-on and the alarm shall remain silenced.

6. Reset: Window lamp for the point affected shall turn off.

7. Test: All window lamps shall flash and the alarm shall remain silent.

G. Each annunciator shall be provided with integrally or remotely mounted auxiliary relays for the following functions:

2. For transmitting “station trouble” condition to a remote annunciator via Authority's supervisory systems, with 125 volt DC coil and double-pole, double-throw contacts, Device 30X. The operation of any annunciator alarm point shall energize the auxiliary relay. The auxiliary relay shall remain energized as long as the alarm condition remains. Relay contacts shall be wired to outgoing terminal blocks of the rectifier auxiliary compartments, readily accessible for external connection to the supervisory terminal (interface) board. Annunciator alarm bell and SCADA auxiliary indication circuits shall be independent.

3. For annunciator DC power supply failure local alarm, Device 74 shall be provided. The coil of the power failure relay shall be connected to monitor the 125-volt DC supply at the annunciator. Associated alarm point on the annunciator shall operate on 120 volt AC supplied from the reliable AC

source located in the DC switchgear.

4. For annunciator bell and flasher cutoff during substation unattended periods, Device 95D with 125 volt DC coil shall be provided. Coil of the relay shall be wired to outgoing wiring terminal block for connection to door security system (intrusion detection). Each substation personnel access door shall be monitored.

1.13 KEY INTERLOCK SYSTEM

A. Rectifier main DC circuit breaker, Device 72R, and rectifier negative lead disconnect switch, Device 89N, shall be provided with a key interlock system to prevent operation of the negative disconnect switch in either direction, unless the rectifier main circuit breaker is open and in fully disconnected position. To open the negative disconnect switch, the following operations shall be performed:

1. Trip the rectifier main DC circuit breaker and rack it into fully disconnected position. The captive key at the rectifier main circuit breaker is now free to be turned and removed. Turning of the key will mechanically block the circuit breaker removable element from being placed into the test and connected position, but will allow the withdrawal of the circuit breaker removable element from its housing.

2. Insert key in the lock at the negative disconnect switch and turn to unlock the operator of the switch. Key is now held captive.

1. Open negative disconnect switch.

2. Reverse sequence to restore service.

B. The 15 kV feeder circuit breaker Devices 52-USS 1 and 52-USS 2 shall be provided with a key interlock system to prevent the opening of the interrupter cubicle door in the unit substations (provided by others) unless the 15 kV feeder circuit breaker is open and in the fully disconnected position and the associated secondary main circuit breaker in the unit substation is open. The Contractor shall coordinate the opening sequence of the interrupter cubicle door with the unit substation equipment. The following is a description of the required sequence of operations.

1. Trip the 15 kV circuit breaker and rack it into the fully disconnected position. The captive key (A) at the circuit breaker is now free to be turned and removed. Turning of the key will mechanically block the circuit breaker removable element from being placed into the test or connected position.

2. Trip the main secondary breaker. The captive key (B) at the circuit breaker is now free to be turned and removed. Turning of the key will lock the circuit breaker in the open position.

3. Insert key (B) into the interlock housing of the interruption switch operating mechanism. Turn key (B) to open interrupter switch. Kirk Key (B) is held captive.

4. Insert key (A) into the interlock housing of the interruption switch. Turning key (A) will allow the door to be opened. Once the door is opened both key (A) and key (B) will be held captive.

5. Mechanical interlocks and/or additional key interlocks shall be provided to prevent the turning and removal of keys (A) and (B) unless both the doors and the interrupter switch are closed. Upon manual closing of the interruption switch, keys (A) and (B) can be turned and removed, locking the manual operator. The keys can now be returned into their respective interlock housings, allowing the closure of the 15 kV and the secondary main circuit breakers for restoration of the service.

C. Tumbler settings of locks shall be different for each interlock system. Information related to lock settings will be furnished to the Contractor by the Engineer.

D. Contractor shall prepare and forward to the Engineer for approval a detailed schematic diagram of each key interlock system supplied, showing the equipment involved and key travel, identifying each component and fully describing the operation. The approved key interlock drawings and data shall be included in the instruction and maintenance manual for the substation equipment.

1.14 SURGE ARRESTERS

A. 15 kV system surge arresters shall be of the intermediate class, suitable for installation in metal clad switchgear. Arresters shall be rated for application on the specific voltage system on which it is being used. The manufacturer shall be responsible to coordinate the size of the surge arresters for the system on which it is being used. Contractor's proposed intermediate class, MOV type, polymer-housed surge arresters will be subject to the approval of the Engineer.

B. Surge arresters associated with the 625-volt nominal DC power system shall be designed to protect DC traction power equipment and distribution circuits. Contractor's proposed polymer-housed, MOV type DC surge arresters will be subject to the approval of the Engineer. DC feeder circuit surge arresters shall be mounted in an insulating protective enclosure external to the DC switchgear. Location and enclosure to be proposed by the Contractor to be subject to approval by the Engineer.

C. Surge arrester for the negative equalizer bus and drainage board shall also be of the metal-oxide type and rated for the intended service.

1.15 FINISH

A. All metalwork shall be carefully finished to remove sharp edges and burrs.

B. All surfaces shall be thoroughly cleaned and treated with a rust inhibiting phosphatized coating prior to painting, then finished with two coats of semi-gloss ANSI-61 light gray paint, unless otherwise specified. Unfinished galvanized steel panels inside the enclosures will not be acceptable.

1.16 DELIVERY

A. Equipment and materials shall be delivered to the site in original containers, suitably sheltered from the elements, but readily accessible for inspection by the Engineer until installed. All items prone to moisture damage, such as control equipment and electrical apparatus, shall be stored in dry, heated spaces. Equipment and materials shall be tightly covered and protected against dirt, water, chemical and mechanical injury and theft. Damage or defects which occur before acceptance of the work shall be repaired or replaced as directed, without additional cost to the Authority.

B. All major electrical equipment shall be shipped with impact indicators attached.

PART 2 – PRODUCTS

(NOT USED)

PART 3 – EXECUTION

(NOT USED)

PART 4 - MEASUREMENT AND PAYMENT

4.01 GENERAL

A. No separate measurement or payment will be made for work required under this Section. All costs in connection therewith will be considered incidental to the item of work to which they pertain.

END OF SECTION